SECTION 605

UNDERDRAINAGE

605.1 Description. This work consists of furnishing and installing underdrains in conformity with the lines and grades shown on the plans or as directed by the engineer and shall include installation of all required drainage media, and backfilling with material as specified or as directed by the engineer.

605.2 Material. All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Aggregate for Drainage	1009
Geotextile	1011
Geocomposite Edge Drain	1012
Drainage Material	1013
Corrugated Metallic-Coated Steel Pipe Underdrain	1022
Corrugated Aluminum Alloy Pipe Underdrain	1025

605.2.1 Except as otherwise specified, all underdrain pipes, tubing or geocomposite cores shall be perforated. All special fittings such as caps, wyes, tees and couplings shall be of standard design and manufacture and shall be compatible with the type of pipe, tubing or geocomposite drain to be used. All steel fittings shall be zinc or aluminum coated. All welds and cuts of steel pipe or fittings shall be repaired, after welding, as allowed in Sec 1020.

605.3 Construction Requirements.

605.3.1 Pipe-Aggregate Pavement Underdrain. This work shall consist of placing a continuous pipe-aggregate pavement underdrain under the edge of new pavement as shown on the plans or as directed by the engineer. The aggregate shall be Grade 3 (except not Sec 1005.1, Gradation A material), 4 or 5 drainage aggregate. If not otherwise shown on the plans, underdrain pipe or tubing shall have a nominal internal diameter of 4 inches (100 mm), the trench width shall be not less than 8 inches (200 mm) plus the nominal diameter of the pipe and the depth of drainage aggregate shall be a minimum of 12 inches (300 mm) above the pipe or tubing.

605.3.1.1 The contractor shall select either plastic or metal pipe or tubing meeting these specifications, except that geocomposite drains shall not be used. Where plastic pipe or tubing is used, any exposed outlet shall consist of metal pipe suitably connected to the plastic except for pavement edge drains. Pavement edge drains shall be provided with outlet pipe and splash pads meeting the requirements of this section.

605.3.1.2 After placement of the underdrain pipe, the initial lift of backfill material shall be placed around and over the pipe to a compacted depth not to exceed 12 inches (300 mm) above the pipe or tubing. This initial lift shall be compacted by three passes of a vibrating pad or drum-type compactor approved by the engineer. Any remaining backfill shall be placed in loose lift thicknesses not exceeding 6 inches (150 mm) and each lift compacted by two passes of the same equipment.

605.3.1.3 If a pipe-aggregate pavement underdrain is used as a pavement edge drain on a pavement rehabilitation project, the contractor shall not install the drain until all pavement repair and required undersealing have been completed in the area where it is to be placed.

605.3.1.4 Pipe-aggregate pavement underdrains under new pavement shall be constructed as shown on the plans. The underdrain shall be lined with geotextile and wrapped. Underdrains underneath stabilized permeable base shall have the geotextile wrapped around the outside edge and over the top of the permeable base.

605.3.2 Structure Underdrain. This work shall consist of placing pipe or tubing of the sizes shown in the plans, Type 1 (Subsurface Drainage) geotextile as required or shown on the plans, and drainage aggregate.

605.3.2.1 When the remaining backfill is coarse aggregate or rock fill, Grade 3, 4 or 5 drainage aggregate shall be used with no geotextile. When the remaining backfill is sand or soil, any drainage aggregate may be used with the following exceptions. For sand backfill and Grades 3, 4 and 5 drainage aggregate or for earth backfill and Grades 2, 3, 4 and 5 drainage aggregate, the backfill material shall be separated from the drainage aggregate with geotextile.

605.3.2.2 The contractor shall select either plastic or metal pipe or tubing meeting these specifications, except that geocomposite drains shall not be used, and where plastic pipe or tubing is used, any exposed outlet shall consist of metal pipe suitably connected to the plastic.

605.3.2.3 After placement of the drain pipe or tubing, the initial lift of backfill material shall be placed around and over the pipe to a compacted depth not to exceed 6 inches (150 mm) above the pipe or tubing. This initial lift shall be compacted by two passes of a vibrating pad or drum-type compactor approved by the engineer. Any remaining porous backfill shall be placed in loose lift thicknesses not exceeding 6 inches (150 mm) and each lift compacted by two passes of the same equipment.

605.3.3 French Underdrain. This work shall consist of the installation of a drain using a trench, Type 1 (Subsurface Drainage) geotextile lining, and Grade 3 or 4 drainage aggregate.

605.3.3.1 Unless otherwise specified, both the trench width and depth of drainage aggregate shall be not less than 18 inches (450 mm). Where directed, the trench above the drainage aggregate shall be backfilled with well compacted suitable earth.

605.3.3.2 Drainage aggregate shall be placed in lifts not to exceed 18 inches (450 mm) in thickness and compacted in a manner meeting the approval of the engineer.

605.3.3.3 All french underdrains shall be daylighted at discharge ends with minimum 10-foot (3 m) lengths of perforated 6-inch (150 mm) diameter metal pipe placed at or within 3 inches (75 mm) of the flowline.

605.3.4 Geocomposite Pavement Edge Drain. This work shall consist of furnishing and installing geocomposite pavement edge drain at the locations and in conformity with the lines and grades, shown on the plans or as directed by the engineer.

605.3.4.1 The contractor shall furnish to the engineer a copy of the drain manufacturer's printed instructions for installing the edge drain at least two weeks prior to installation. Except as herein noted, the installation of the drain shall be in accordance with the manufacturer's printed instructions.

605.3.4.2 After installation, the drain shall be promptly backfilled, compacted and covered.

605.3.4.3 The drain shall be placed against the pavement side of the trench and held in place while backfill is placed to a compacted height of 6 inches (150 mm), plus or minus 1 inch (25 mm), using a vibratory wheel or plate compactor with a rated impact force of approximately 5000 pounds (34 MPa). The placement of the edge drain and placement of the first lift of backfill shall be accomplished in a single continuous operation. After the first lift of backfill has been placed, the remainder of the backfill shall be placed and compacted by a vibratory compactor to the satisfaction of the engineer. Material excavated from the trench may be used for backfill, except that all backfill shall pass a 2-inch (50 mm) sieve. At the contractor's option, Grade 1 drainage aggregate may be used in two lifts and flooded with clean water to compact each lift. In that case, the drain shall be placed against the shoulder side of the trench.

605.3.4.4 Each length of drain shall be joined to the adjacent length prior to installation. Splices shall keep adjoining lengths in proper alignment, shall not separate during installation, shall have the same or greater compressive strength than the geocomposite drain and shall be sealed against infiltration of the backfill material.

605.3.4.5 The contractor shall not install the drain until after all pavement repair and required undersealing have been completed in the area where edge drain is to be placed.

605.3.5 Outlet Pipes and Splash Pads. This work shall consist of furnishing and installing outlet pipes and splash pads for pipe-aggregate pavement edge drain and geocomposite pavement edge drain at the locations and in conformity with the lines and grades shown on the plans or as directed by the engineer.

605.3.5.1 Unless otherwise shown, outlet pipes shall be installed perpendicular to the drain, with a minimum of two percent gradient and kept as far as possible above the ditch flowline.

605.3.5.2 Concrete for splash pads shall be air-entrained and Class B, B-1 or concrete of a commercial mixture meeting the requirements of Sec 501.

605.3.5.3 Construction requirements for the splash pads shall be in accordance with the applicable requirements of Sec 609. In addition, the contractor shall perform the excavation necessary for the construction of each splash pad in such a manner that a minimal amount of backfilling will be necessary. If the excavation is done to neat lines, forming will not be required.

605.3.5.4 Outlet pipes shall be 4-inch (100 mm) diameter non-perforated, schedule 40 PVC pipe. Outlet connections to pipe-aggregate pavement edge drains shall be with "two way cleanout" connectors.

605.3.5.5 Outlet pipe trenches shall not be cut prior to installation of the edge drain. Outlet installation shall be completed promptly and, in all cases, within 72 hours of edge drain installation except with the express approval of the engineer. The trench shall not be backfilled until the installation is inspected and approved by the engineer.

605.3.5.6 Backfilling of excavations for outlet pipe and splash pads shall be performed in accordance with applicable provisions of Sec 203. Should additional material be needed to complete the backfill, suitable material meeting the approval of the engineer shall be provided by the contractor at no additional cost.

605.3.6 General Geotextile Requirements. Except where otherwise provided in the plans or contract, Type 1 (Subsurface Drainage) geotextile shall be provided with all pipe-aggregate and french underdrains.

605.3.6.1 Except as otherwise specified, geotextile shall be used to line underdrain trenches and to completely envelope any drainage aggregate in trenches except that a geotextile will not be required when Grade 1 drainage aggregate is used. Only partial envelopment may be required when the underdrain abuts or is overlain by an approved open graded base course or other drainage medium.

605.3.6.2 A drainage geotextile wrap or sock shall envelope perforated drainage pipe or tubing when Grade 1 or 2 drainage aggregate is used, or whenever any portion of a perforated pipe used as a discharge pipe is backfilled with soil.

605.3.6.3 During shipment and storage, geotextiles shall be protected from direct sunlight, ultra-violet rays, temperatures greater than 140 F (60 C), mud, dust and debris.

605.3.6.4 Geotextile for structure drains shall be as shown in the plans.

605.3.7 General. Although probable locations of underdrains are shown on the plans, the contractor shall perform work only at such locations as are specified or approved in writing by the engineer.

605.3.7.1 Trenches for underdrains shall be carefully excavated true to line and grade and to the width and depth shown on the plans or as directed by the engineer.

605.3.7.2 Any underdrain trenching which results in an uneven trench bottom or exposes soft, yielding or unstable ground in the trench bottom shall be undergraded as required and backfilled with drainage aggregate material of sufficient thickness to ensure maintenance of proper alignment and gradient for all subsequent operations.

605.3.7.3 Any required drain pipe or tubing shall be firmly bedded and carefully aligned. The pipe or tubing shall be laid with perforations down if the perforations are not uniformly distributed around the circumference of the pipe or unless otherwise shown in the plans. Sections shall be jointed with approved fittings. Dead ends of pipe shall be completely closed by means of caps or plugs. Outlets shall be protected with rodent screens inserted a distance equal to one to two pipe diameters in a manner ensuring a secure friction-tight fit. Where shown on the plans or directed by the engineer, the outlet ends shall be connected to drain into drop inlets or manholes.

605.3.7.4 Backfilling shall be carefully done so that any included pipe or tubing will not become displaced. The required drainage aggregate material shall be placed to the dimensions shown on the plans and as specified herein.

605.4 Method of Measurement. Measurement will be made to the nearest linear foot (0.5 m) for each type of underdrain along the centerline of the drain, center to center of fittings and junctions.

605.5 Basis of Payment.

605.5.1 The accepted quantity of each type of underdrain, complete in place, will be paid for at the contract unit price per linear foot (meter), or at an adjusted unit price per linear foot (meter) as described herein. Any overrun or partial or complete underrun of contract quantity will not be considered as basis for claim. No direct payment will be made for excavating the trench, connecting underdrains to drop inlets or manholes, nor for backfilling and backfill material. Outlet pipes will not be separately paid for except in combination with any required splash pad.

605.5.2 Adjustments in the contract unit price per linear foot (meter) of underdrain will be made in accordance with the following schedule where the engineer directs increased depth of excavation from that shown in the plans. For purposes of determining the adjusted price, the excess depth of excavation will be averaged for the entire length of the drain if less than 100 feet (30 m) and, if more than 100 feet (30 m), shall be subdivided into 100-foot (30 m) increments plus any remaining fraction. Any required undergrading to provide 3-inch (75 mm) bedding of drainage aggregate where geotextile trench lining is omitted shall not be included in any calculation of excess depth of excavation for pay purposes.

Average Excess Depth of Excavation	Adjusted Price
0 to 6 inches (0 to 150 mm)	Contract Price
6 to 18 inches (150 to 450 mm)	Contract Price + 25%
18 to 30 inches (450 mm to 750 mm)	Contract Price + 50%
> 30 inches (750 mm)	To be established by supplemental agreement

605.5.3 Eight-inch (200 mm) non-perforated underdrain pipe used with drain basins will be paid for at the contract unit price. Excavation for placing the pipe will be measured and paid for as Class 3 Excavation in accordance with Sec 206.

605.5.4 Payment for plan quantity of outlet pipes and splash pads, in combination, will be made at the contract unit price bid per each "Splash Pad".

SECTION 605.10 CLASS A UNDERDRAIN

605.11 Description. This work shall consist of pipe placed for subdrainage purposes in conformity with the lines and grades shown on the plans or as directed by the engineer, and shall include excavating the trench and backfilling with material as specified or directed.

605.12 Material. All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	1009.2
Corrugated Metallic-Coated Steel Pipe Underdrain	1022
Corrugated Aluminum Alloy Pipe Underdrains	1025

The contractor may select the type of underdrain pipe proposed to be furnished.

605.12.1 Except as otherwise specified, all underdrain shall have a nominal internal diameter of 6 inches (150 mm) and shall be perforated. All special fittings, including caps, wyes, tees, reducers, elbows, turns and couplings, shall be of standard design and manufacture. All couplings, joints and all special fittings shall be galvanized after welding or all welds and metal adjacent to the welds shall be painted, after welding, with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer. Screens shall be of 2 x 2 mesh, No. 19 gage (1 mm), galvanized wire cloth, approximately 1/2-inch by 1/2-inch (13 x 13 mm) openings.

605.13 Construction Requirements.

605.13.1 Although probable locations of underdrains are shown on the plans, the contractor shall perform work only at such locations as are specified in writing by the engineer.

605.13.2 The trench for underdrains shall be carefully excavated true to line and grade and to the width and depth shown on the plans or as directed by the engineer.

605.13.3 The pipe shall be firmly bedded in the trench. Pipe sections shall be joined with approved connecting bands. Dead ends of pipe shall be completely closed by means of caps securely affixed to the pipe. Discharge ends shall be protected with screens securely fastened in place by means of galvanized wire. Where shown on the plans or directed by the engineer, the outlet ends shall be connected to drain into drop inlets or manholes.

605.13.4 Backfilling shall be carefully done so that the pipe will not become displaced. The required porous backfill material shall be placed to the dimensions shown on the plans.

605.14 Method of Measurement. Measurement will be made to the nearest linear foot (0.5 m) for each underdrain along the centerline of the drain, center to center of fittings and junctions.

605.15 Basis of Payment.

605.15.1 The accepted quantity of Class A underdrain, complete in place, will be paid for at the contract unit price per linear foot (meter), or at an adjusted unit price per linear foot (meter) as determined in Sec 605.15.2. Any overrun or partial or complete underrun of contract quantity will not be considered as basis for claim. No direct payment will be made for excavating the trench, connecting underdrains to drop inlets or manholes, nor for backfilling and backfill material.

605.15.2 For the purpose of determining the price to be paid per linear foot (meter) of underdrain, the underdrain will be laid off in 10-foot (3 m) increments beginning at one end of the pipe, and the space below the elevation of the bottom of the trench on the plans shall be divided into 12-inch (300 mm) depth increments; only the nearest full increment will be considered in either case. If the average depth of trench excavated in a 10-foot (3 m) increment is not more than 6 inches (150 mm) below the depth shown on the plans, adjustment in the unit price will not be made and the contract price shall apply. If the average depth of trench in a 10-foot (3 m) increment is more than 6 inches (150 mm) and not more than 18 inches (450 mm) below the plan elevation of the bottom of the trench, underdrains, within such horizontal limits, will be paid for at 125 percent of the contract unit price. If the average depth is more than 18 inches (450 mm) and not more than 30 inches (750 mm), payment will be at 150 percent of the contract unit price; for any 12-inch (300 mm) increment of depth, or fraction thereof, below the 30-inch (750 mm) depth, 25 percent of the contract unit price will be added.

605.15.3 Eight-inch (200 mm) unperforated underdrain pipe used with drain basins will be paid for at the contract unit price. Excavation for placing the pipe will be measured and paid for as Class 3 Excavation in accordance with Sec 206.

SECTION 605.20 CLASS B UNDERDRAIN

605.21 Description. This work shall consist of pipe (generally for draining porous or other backfill adjacent to concrete masonry construction) placed in conformity with the lines and grades shown on the plans, or as directed by the engineer. The underdrain pipe shall be of the size or sizes shown and may be corrugated metal, perforated corrugated metal or combinations of such pipe unless a specific type is specified in the contract. Perforated pipe shall be laid in a prepared bed of porous backfill.

605.22 Material. All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	1009.1
Corrugated Metallic-Coated Steel Pipe Underdrain	1022

Pipe underdrains shall be perforated unless otherwise specified in the contract.

605.22.1 All special fittings, including caps, wyes, tees, reducers, elbows, turns and couplings, shall be of standard design and manufacture. All couplings, joints and all special fittings shall be galvanized, after welding, or all welds and metal adjacent to the welds shall be painted after welding with two coats of single component inorganic zinc or organic zinc-rich paint, meeting the approval of the engineer.

605.23 Construction Requirements. The pipe shall be laid to the grade and alignment shown on the plans, with the perforations down. The pipe shall be joined with approved coupling bands. Where a section of pipe is cast into concrete, the remaining pipe shall be joined to these sections with connecting bands. The porous backfill material shall be placed so that the pipe will not become displaced and shall be firmly tamped under and around the entire pipe. Discharge ends shall be protected by approved methods to prevent obstruction until connections to outlets are installed.

605.24 Method of Measurement. Measurement will be made to the nearest linear foot (0.5 m) for each underdrain along the centerline of the pipe, center to center of fittings and junctions.

605.25 Basis of Payment. The accepted quantity of Class B underdrain, complete in place, will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for excavating the trench nor for backfilling and backfill material.

SECTION 605.30 CLASS C UNDERDRAIN

605.31 Description. This work shall consist of either a French underdrain or a drain tile underdrain, or combinations of these types placed in conformity with the lines and grades shown on the plans, or as directed by the engineer. The type of underdrain to be constructed at a particular location will be shown on the plans.

605.32 Material. All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Porous Backfill Material	1009.2
Clay Drain Tile	1031

If drain tile underdrain is specified in the contract, the contractor may select the type of underdrain tile proposed to be furnished.

605.33 Construction Requirements.

605.33.1 Although probable locations of underdrains are shown on the plans, the contractor shall install underdrains only at such locations as are specified in writing by the engineer.

605.33.2 Drain Tile Underdrain. The trench shall be carefully excavated to the width and depth required to permit the tile to be laid to the proper grade. The tile shall be bedded firmly in the trench with ends closely joined and each section of the tile shall have a firm bearing throughout its length. The top of all joints shall be covered with strips of tar paper not less

than 8 inches (200 mm) wide. No joint opening shall be more than 1/2 inch (13 mm) and any joint opening 1/4 inch (6 mm) or more shall have a piece of broken tile placed over the tar paper covering. All junctions, bends and turns shall be made with fittings of standard manufacture. Suitable caps or plugs shall be provided and installed to close the dead ends of the underdrains. Screens of 2 x 2 mesh, No. 19 gage (1 mm), galvanized wire cloth, approximately 1/2-inch by 1/2-inch (13 x 13 mm) openings, shall be provided and securely fastened over the outlet ends by means of galvanized wire. Any tile which is not in true alignment or which shows signs of settlement after it has been laid shall be taken up and relaid to the proper grade.

605.33.2.1 Backfilling shall be carefully done so that the tile will not be displaced. Porous backfill shall be placed to the dimensions shown on the plans and covered with a layer of tar paper as indicated. For that part of the trench in shoulders, the trench above the porous backfill shall be filled with suitable backfill, well compacted. Underdrains shall be kept free from accumulations of silt, debris and other foreign matter during construction.

605.33.3 French Drain. At locations shown on the plans, French drains shall be constructed in the subgrade and through the shoulders to provide drainage. French drains shall have a trench of the dimensions shown on the plans, filled with porous backfill material. For that part of the trench in shoulders, the trench above the porous backfill shall be filled with suitable earth, well compacted.

605.34 Method of Measurement. Measurement will be made to the nearest linear foot (0.5 m) for each underdrain.

605.35 Basis of Payment. The accepted quantity of Class C underdrain, complete in place, will be paid for at the unit price for each of the pay items included in the contract. Any overrun or partial or complete underrun will not be considered as a basis for claim. No direct payment will be made for excavating the trench nor for backfilling the backfill material.